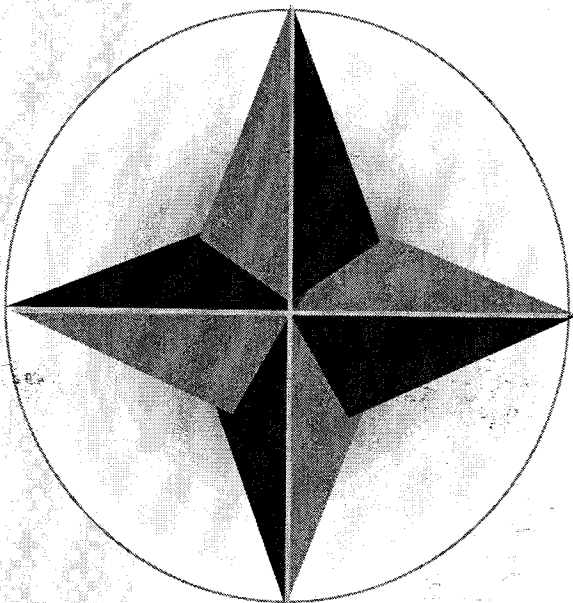


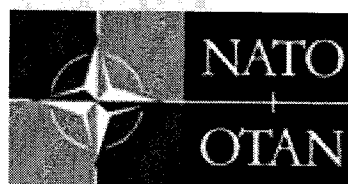


Research & Technology Organisation



Manager's Guide to the High Level Architecture for Modelling and Simulation (HLA)

Mr. Robert Elliott, Canada, DND SECO
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North Atlantic Treaty Organisation

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MAY 4 2009 4

Office of Security Review

Department of Defense

ITEC 2009
11 May 2009

ITEC 2009
20090430 - Slide 1



09-S-1704



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ITEC 2009
11 May 2009

Outline

Objective

M&S Introduction

HLA Overview

**Federation Resource
Considerations**

**Federation Development
Process**

Use Cases

Summary and Wrap Up

Objectives

- **Benefits of using modelling and simulation**
- **Issues to be considered to implementing M&S and HLA**
- **Basic understanding of HLA concepts**
- **Benefits of using HLA**
- **Systems engineering process for HLA**
- **Resources required to effectively employ HLA**

Outline

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Topics

- What is M&S?
- Value of M&S
- Distributed simulation
- Interoperability
- Verification and validation

What is Modelling and Simulation (M&S)

✓ M&S is:

- a representation of the real world
- an enabling tool that improves our lives today, prepares us for a better tomorrow, and provides a means to meet national and international security challenges

✓ M&S technology and processes:

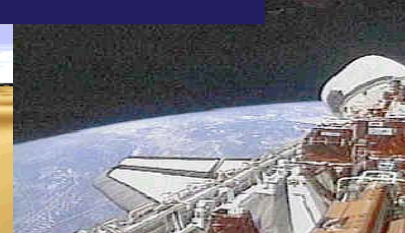
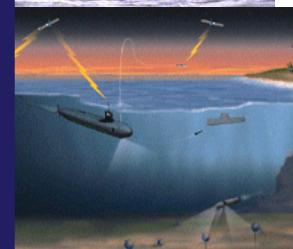
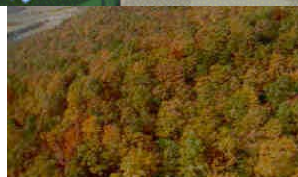
- exist everywhere in our lives
- used extensively for acquisition, analysis, experimentation, planning, testing and training



What is Modelling and Simulation?

An attempt to represent real world:

- Processes
- Equipment
- People
- Activities
- Environments

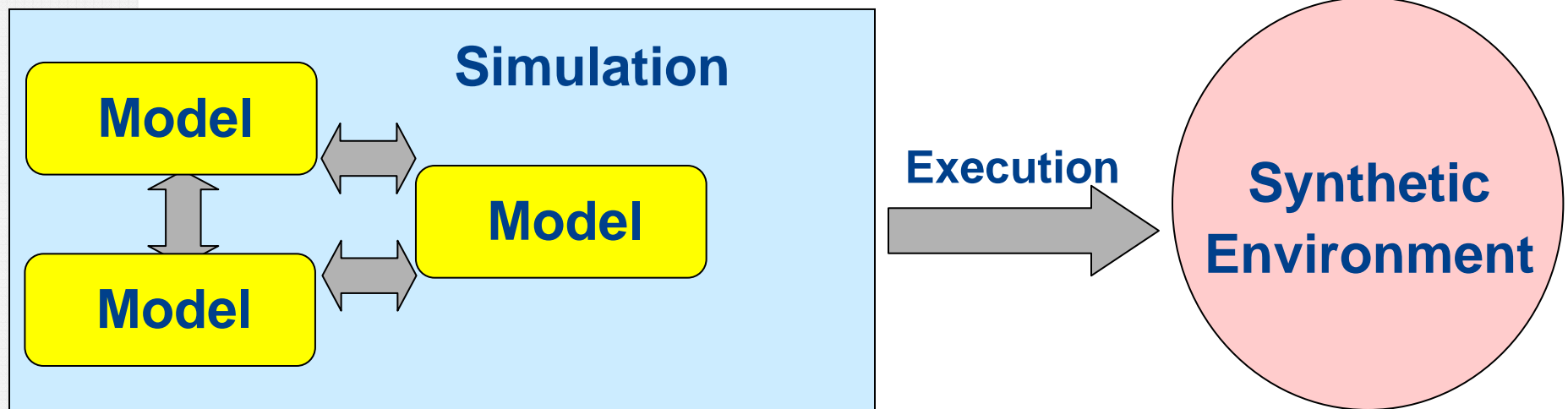


Why M&S

- Aid for:
 - Thought (Help develop and explore issues)
 - Communication (Picture worth 1,000 words)
 - Training and Instruction
 - Experimentation
 - Prediction
- Improves capabilities

Canadian source

Basic M&S Terminology



- **Model** A representation of a system, entity, phenomenon, or process. Software models of specific entities are comprised of algorithms and data. *Source: NATO Modeling and Simulation Master Plan*
- **Simulation** The execution over time of models representing the attributes of one or more entities or processes. Human-in-the-Loop simulations, also known as simulators, are a special class of simulations. *Source: NATO Modeling and Simulation Master Plan*
- **Synthetic Environment** A representation of the world as defined by the simulation and models. *Canadian Source*

Types of Simulations

- **Live** - Simulation involving real people operating real systems
- **Virtual** - Simulation involving real people operating simulated systems
- **Constructive** - Simulation involving simulated people operating simulated systems. Real people can stimulate (make inputs) but are not involved in determining outcomes.

Types of Simulations – Live

Live Simulation - A simulation involving **real people** operating **real systems**.

Live simulations:

- involve individuals or groups
- may use actual equipment
- should provide a similar area of operations
- should be close to replicating the actual activity

Types of Simulations - Virtual

***Virtual Simulation* - A simulation involving real people operating simulated systems.**

***Virtual simulations* inject human-in-the-loop in a central role by exercising:**

- **motor control skills** (e.g., flying an airplane)
- **decision skills** (e.g., committing fire control resources to action)
- **communication skills** (e.g., members of a C4I team)

Types of Simulations - Constructive

Constructive Simulation - Simulations that involve **simulated people** operating **simulated systems**. Real people stimulate (make inputs) to such simulations, but are not involved in determining the outcomes.

Constructive simulations offer the ability to:

- analyze concepts
- predict possible outcomes
- stress large organizations
- make measurements
- generate statistics
- perform analysis

How M&S is Used

- M&S as a *primary enabling technology* necessary to effectively meet objectives in an affordable, reusable and interoperable context
- Use M&S in relation to:
 - Concept development and experimentation
 - Materiel acquisition and support
 - Joint and combined training and mission rehearsal
 - Development of doctrine and tactics
 - Formulation of new operational plans and capabilities
 - Assessment of war fighting
 - Support for technology assessment, system upgrade, prototyping, full-scale development and forces structuring
 - Enable testing in realistic environments that may not be practical for live testing

Value of M&S

- **Saves Lives**
 - M&S supports real-world applications that save lives.
- **Saves Taxpayers Dollars**
 - M&S supports real-world applications that preserve taxpayer dollars and accelerate the search for solutions to national challenges.
- **Increases Operational Capability**
 - M&S provides strategic operations and support functions to our military, aids plans for national disaster responses and emergency preparedness, fosters and maintains our strategic partnerships, and enhances economic competitiveness globally.

Why Use M&S

- **Enables the representation of a piece of the real world (or a conceptual world) to allow examination of factors of interest in a controlled manner.**
- **Provides preliminary design capability of both processes and physical entities to identify potential problems**
- **Provides capability to examine interactions of multiple entities to assess performance**
- **Offers opportunity to examine the effects of high risk situations in a safe manner**
- **Offers the potential to reduce costs and compress schedules**

Canadian source

Using M&S to Reduce Programme /Project Risk

- **Use of M&S can offer preliminary assessments of a process or system to help avoid errors of conception, construction, or commission**
- **M&S can provide representative education and training in an environment similar to the real world**
- **M&S can provide a synthetic environment to enable rehearsal of processes and missions in a realistic setting**
- **It is an effective communication tool to demonstrate and convey performance and design concepts and requirements**

Canadian source

M&S Challenges Across Communities

- **Usability, Reliability & Affordability (Time, Manpower)**
- **Rapid Scenario Generation Capabilities**
- **Multi-Resolution Environments**
- **Human-Organizational Behavior Representation**
- **Multi-Level Security Issues**
- **Large-Scale Distributed Simulations**
- **C4ISR Systems Interface and Integration**

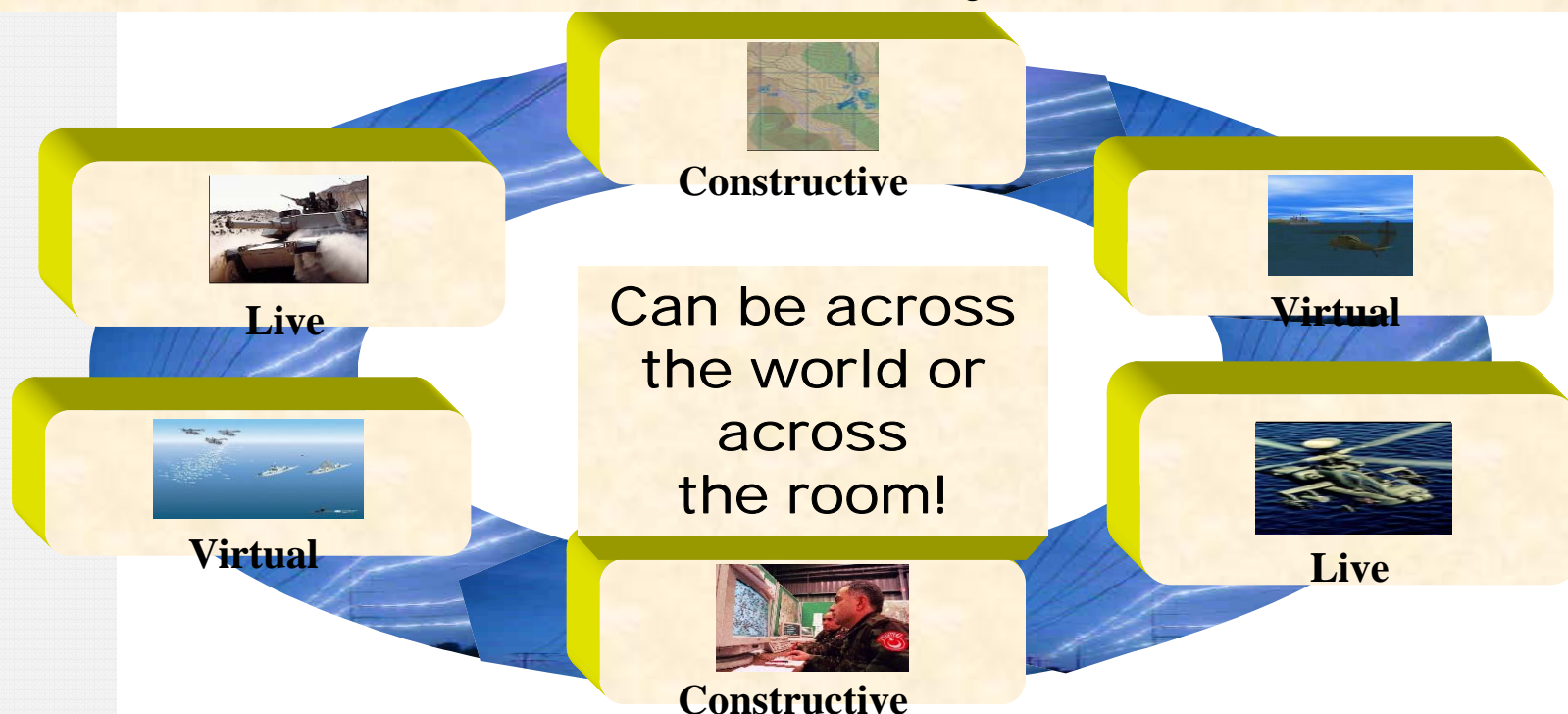
Risks of Using M&S

- **Understanding the simulation objective**
- **Selecting the appropriate type/mix of simulation (live, virtual, constructive)**
- **Choosing the correct resolution and fidelity**
- **Following a disciplined building process**
- **Providing the correct supporting databases**
- **Adequate resourcing for the effort**
- **Presentation of the results in an understandable context**

Canadian source

Concept of Distributed Simulation

Simulations are interactive through current state-of-the-art communication systems.



- Simulation environments that are distributed across multiple computers, potentially at different locations
- Often referred to as “federations”

Why Use Distributed Simulation

- **Allows adaptation to changing requirements**
- **Connects simulation capability that may be in several locations, thus no requirement to move**
- **Increases processing capacity**
- **Enables the combination of Live, Virtual, Constructive simulations**
- **Enables the interaction of users and observers at different locations**
- **Reuses existing capabilities**

Canadian source

History of Distributed Simulation

■ **SIMNET**

- 1980's - development
- 1987 - Fielded

■ **DIS**

- 1992 – First I/ITSEC Demo
- 1993 – First IEEE 1278 standards
- 1998 – DIS Amendment
- 2009 – DIS continues to evolve through SISO

■ **ALSP**

- 1990 - First DARPA initiative
- 1992 – Confederation exercises

■ **HLA (see other slides)**

■ **TENA**

- 2002 - Architecture Document published
- 2002 – Used in Millennium Challenge
- 2009 – TENA continues to evolve

■ **LVC Architecture Roadmap**

- 2007 – Initiated
- 2009 – Final report

Principles of Distributed Simulation

In most cases the following principles are applied:

- **Simulator systems on a common network**
- **Ground truth about entities is shared on network:**
 - Position
 - Orientation
 - Velocity, roll rates
 - Appearance
 - Damage state
 - NOT internal info e.g. fuel level, ammunition load
- **“I tell you I’ve shot you, you work out the damage”**
- **Detection based on own sensor and environment model**

Distributed Simulation Components

- **Terrain**
- **Live Systems**
- **Computer Generated Forces**
 - JSAF, OOS
- **Manned Simulators**
 - Full motion
 - Fixed
- **C2 Systems**
 - SA Displays
 - Chat/email
- **Logging and Analysis**
- **Viewers**
- **Radio Comms**

Distributed Simulation Information Products

- Object Model (Format)
- Object Model (Content)
- Service Specification
- Architecture Spec and Rules
- Security Rqmts/Plan
- Enumerations
- Standard Algorithms
- Data Logging / Collection
- Federation Management (SE Process)
- Scenario
- Conceptual Model
- Test Plan
- Requirements / Objectives
- VV&A Products/Plan
- Terrain Databases
- Environmental Databases
- METOC Databases
- Attrition computation policy
- Byte Ordering
- Network Architecture
- MOE/MOP metrics

Time Management

■ Real-Time simulations

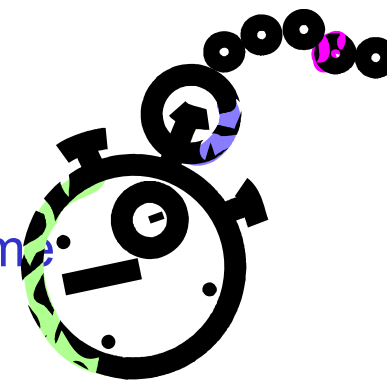
- Meet visual perception and high performance requirements
- Must proceed at wall clock time

■ Event-Stepped simulations

- Event driven requires causality to be maintained
- May proceed either faster, slower or at wall clock time

■ Management Approaches

- No Time Management
 - Each Simulation Advances Time at Its Own Pace
- Conservative Synchronization
 - Simulations Advance Time Only When Guaranteed That No Past Data Will Be Received
- Optimistic Synchronization
 - Free to Advance Logical Time, May Have Roll-back
- Activity Scan
 - Advance Time by Mutual Agreement With Other Simulation



Distributed Simulation Options

- **There are several options to enable distributed simulations:**
 - High Level Architecture HLA (IEEE 1516)
 - Distributed Interactive Simulation (IEEE 1278)
 - Testing and Training Enabling Architecture (TENA)
 - and others
- **Each has its pros and cons. For the purposes of this tutorial we will use HLA**

The Concept of Interoperability

Interoperability is the ability of multiple simulations to **communicate AND interact.**

A example of interoperability is an international telephone call.
Both the technology and the language must be compatible.



Why Interoperability for M&S?



- **Today's operations are joint and combined so we need to train together.**
 - Defense operations: Army, Navy, Air Force, etc
 - National and International
 - OOTW: Peace support operations, Crisis management, Civil security. This also involves civilian entities
 - All levels: from tactical/operational to command and control/strategic/theater level
- **Need to procure from different suppliers/organizations**
- **Different domain modeling and simulation expertise is found in different organizations**
- **Open acquisition model for competitive price/performance.**
- **Economics of modeling and simulations, for example reuse**

Considerations for Distributed Simulations

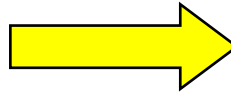
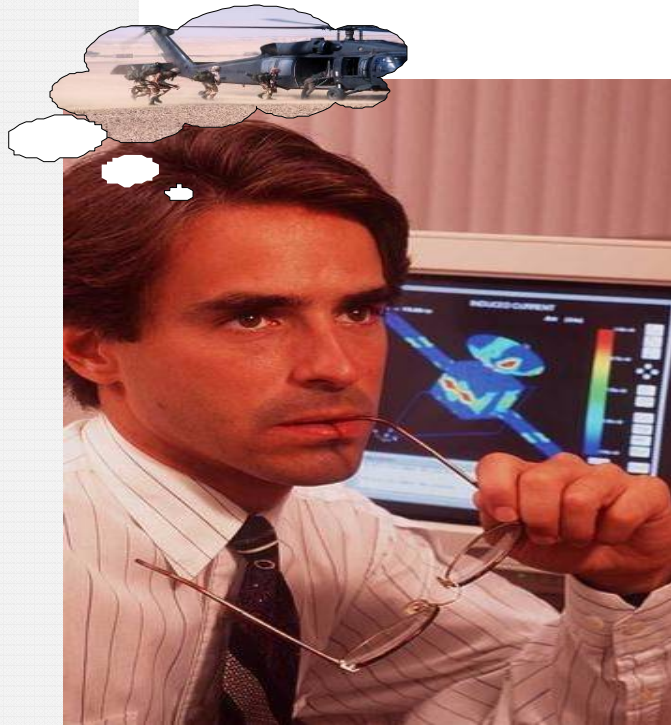
- **Network capability** – bandwidth and quality of service
- **Security** - is a secure network required and are the various locations accredited for secure use
- **Network support tools** – does the network have the required support tools available to enable the simulation developers and operators to communicate and resolve problems
- **Common simulation tools** – does the simulation have a common tool to manage the simulation, exchange the required data and monitor performance
- **Simulation interoperability** – are the various parts of the simulation interoperable; both technically and contextually

Canadian source

The Purpose & Importance of Verification, Validation, and Accreditation

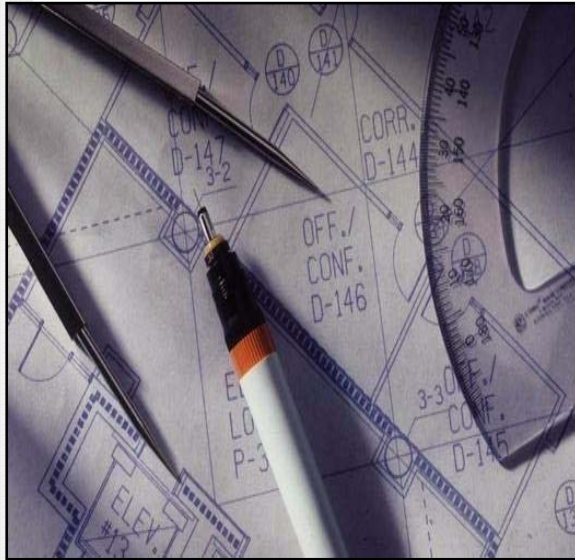
- **Provide credibility to the simulation results through a disciplined approach**
- **Ensure Fit for Purpose**
- **Provide Documented Evidence of what was tested**
- **Provide a documented basis for formal Accreditation where required**
- **Provide a documented reference history to assess possible reuse**

Verification



- The process of determining that a model implementation accurately represents the developer's conceptual description and specifications.
- Provides information about M&S attributes that is used to assess & demonstrate suitability
- **Goal: Did I build it RIGHT?**

Validation



- The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.
- Provides information about M&S attributes that is used to assess & demonstrate suitability
- Goal: Did I build the RIGHT thing?

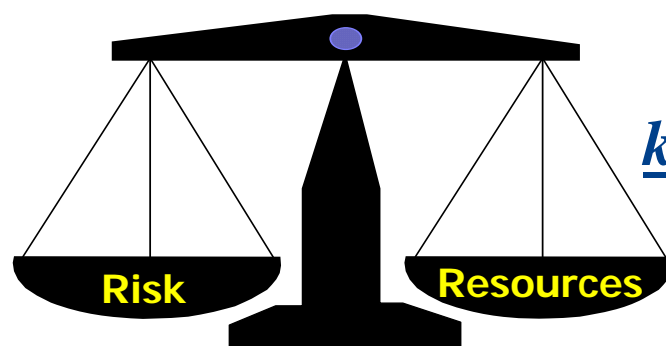
Accreditation



- The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose.
- The certification is based on the accreditation assessment.
- Goal: Are the results of the M&S FIT FOR PURPOSE and USEFUL for making decisions?
- Other commonly used terms are “acceptance” and “fit for purpose”

VV&A Considerations

- Efficient V&V is conducted concurrently with model development
- A precise specification of the intended purpose is essential
- V&V of a simulation model does not equal quality assurance of eg. Software
- Meaningful validation requires sufficient data, information, and knowledge about both the system of interest and the simulation model
- Cost-efficient V&V is risk-driven



Balancing the cost of knowing against the risk of assuming.

Where Does VV&A Apply?

New M&S Development

Any stand-alone model or simulation under development being built to address the intended purpose or purposes of the User.

Legacy

Any model or simulation that was developed either in the past or for a different purpose.

Federation

A system of interacting models and/or simulations, with supporting infrastructure, based on a common understanding of the objects portrayed in the system.

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Topics

- Motivation
- History
- Core concepts
- Upcoming changes
- Standards
- Compliance testing

HLA Motivation

- **Basic Premises:**
 - No single, monolithic simulation can satisfy the needs of all users
 - All uses of simulations and useful ways of combining them cannot be anticipated in advance
 - Future technological capabilities and a variety of operating configurations must be accommodated
- **Need composable approach to constructing simulation federations**
- **HLA evolved from key Aggregate-Level Simulation Protocol (ALSP) and Distributed Interactive Simulations (DIS) architectural decisions**

High Level Architecture Strengths

- The HLA is an internationally recognised Open Standard (ref: IEEE 1516.x)
- Scalability - can scale up to very large exercises, e.g. 1000's of simulation entities
- The architecture can be implemented across different computing environments
- Provides a process for developing and documenting a distributed simulation interface specification, i.e. the Federation Object Model (FOM)
- Supports real-time, faster than real-time and event driven time domains
- The HLA has been proven to work

Source: UK IMMSA Guide, DSTL

High Level Architecture

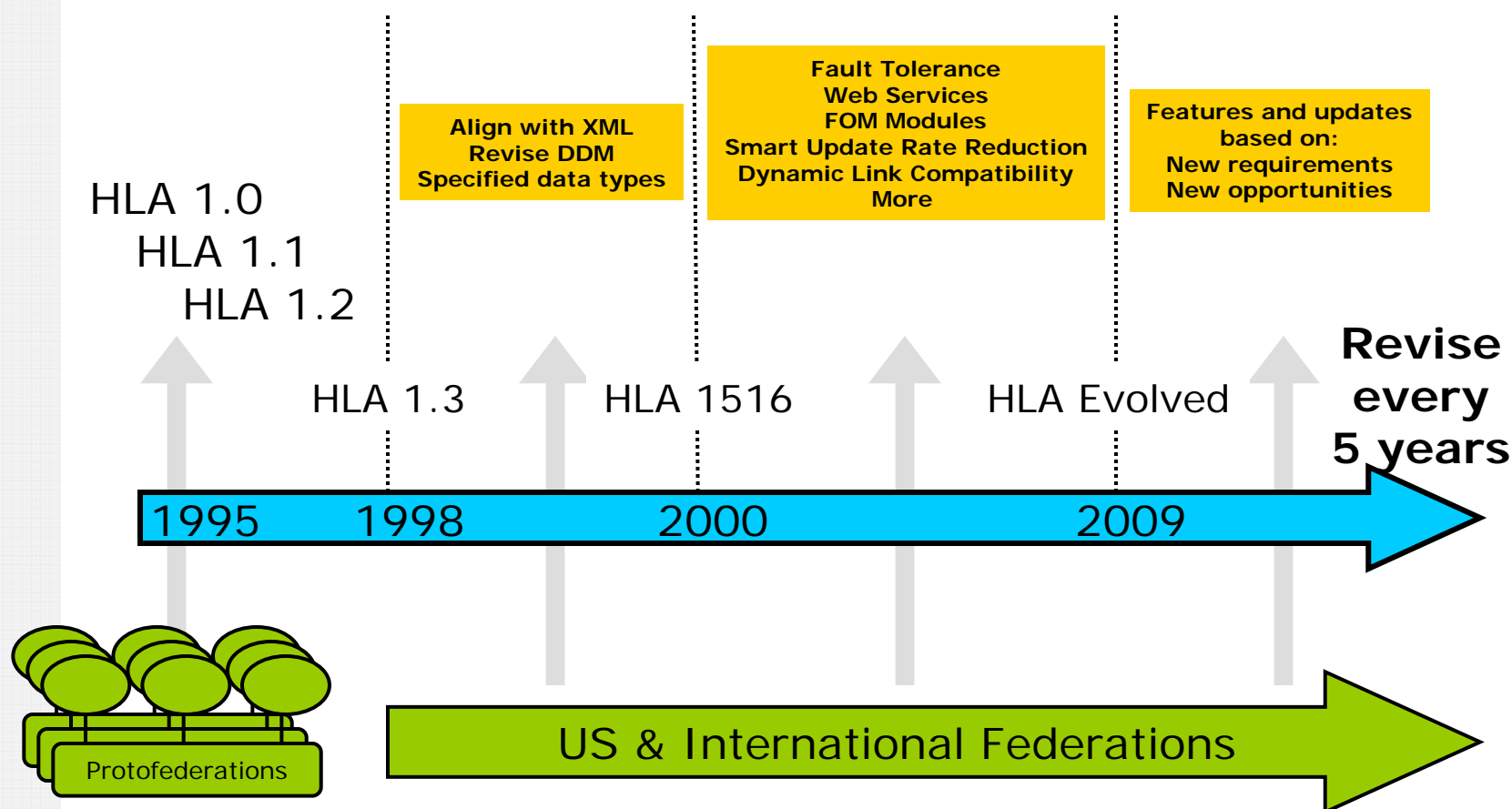
- **The objectives of the HLA are to:**
 - Establish a **common development and execution architecture** to facilitate the interoperability of all types of models and simulations (including real-time, faster than real-time, event-driven simulations and command and control systems)
 - Facilitate the **re-use** of Modelling & Simulation (M&S) components
- **The High Level Architecture (HLA) is not an implementation but is a documented open architecture,**
- **The High Level Architecture is comprised of three elements:**
 - A set of **HLA Rules** for Federates and Federations which define relationships among federating compliant simulations
 - An **Object Model Template (OMT) Specification** which specifies the form in which simulation elements are described
 - An **Interface Specification** which describes the way compliant simulations interact during operation

HLA Issues

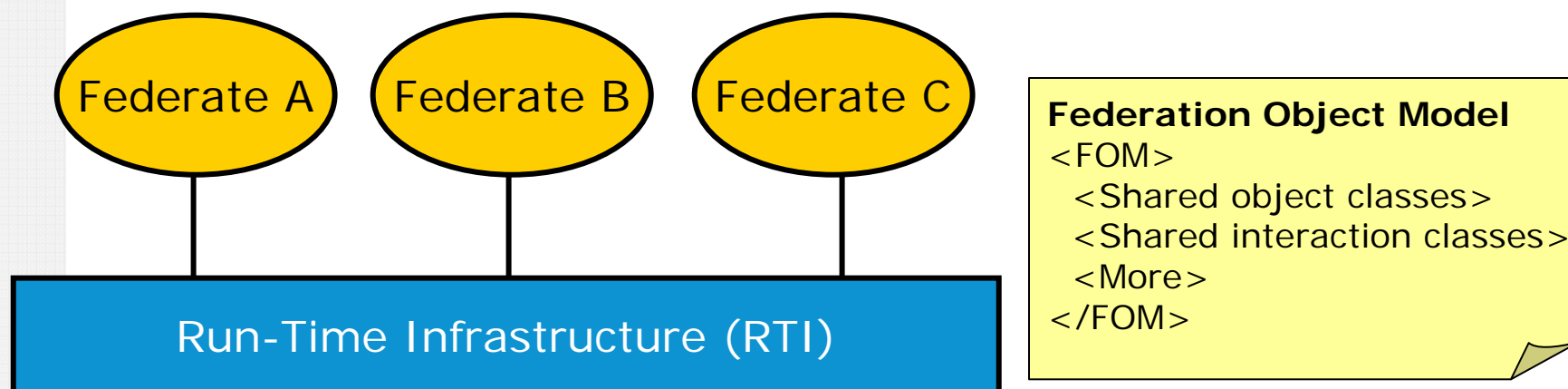
- **As an open standard, changes to the specifications may occur based on consensus**
- **Changes to future HLA standards may have significant impact on local implementations**
- **Migration from earlier versions (US DoD version) to the open standards IEEE version has been slow in some countries**
- **High dependence on vendors for software tools**

HLA – Past, Present and Future

A Technical Perspective

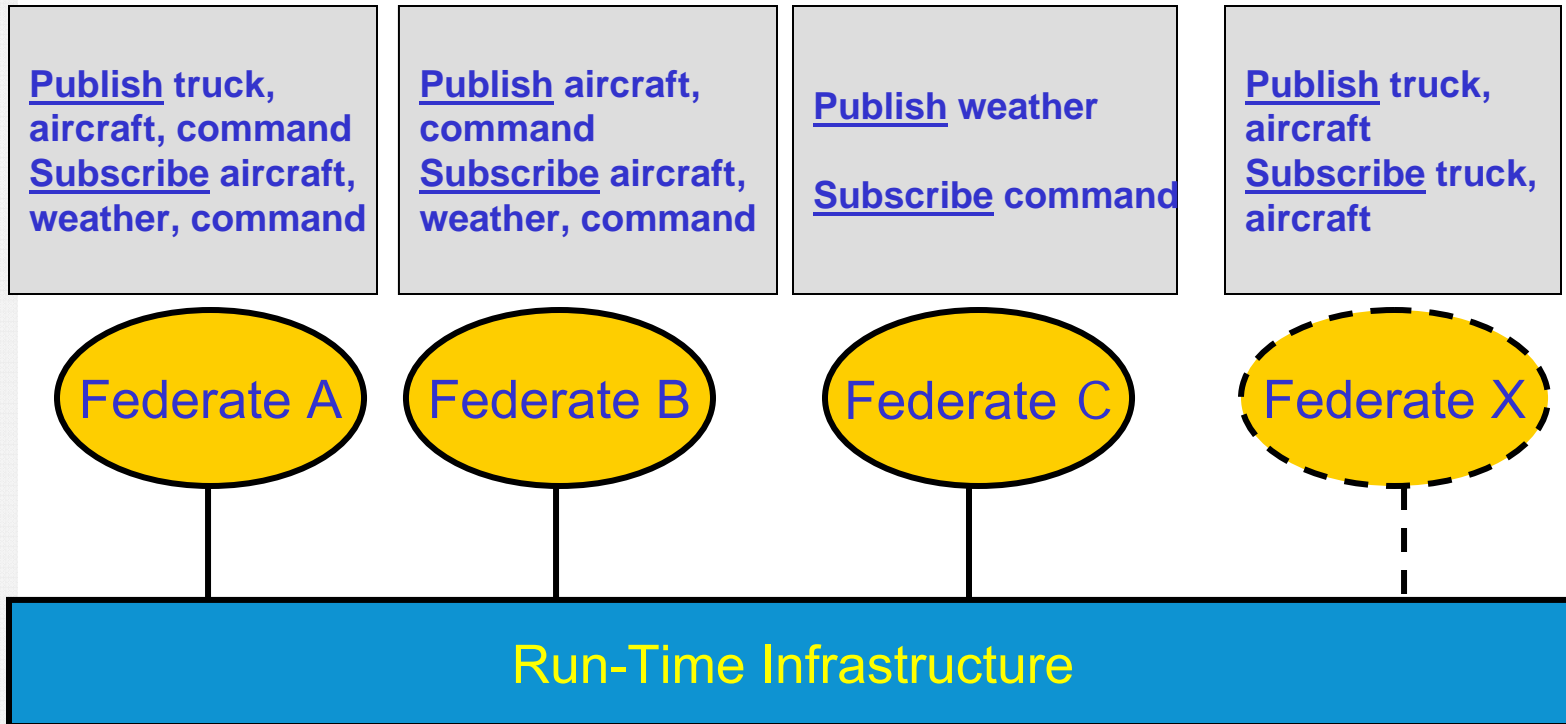


The Classic HLA "Lollipop" View



- Each participating member is called a federate
- Information is exchanged using an RTI
- The information exchange follows a Federation Object Model (FOM)
- The participating federates together with the FOM are called a federation

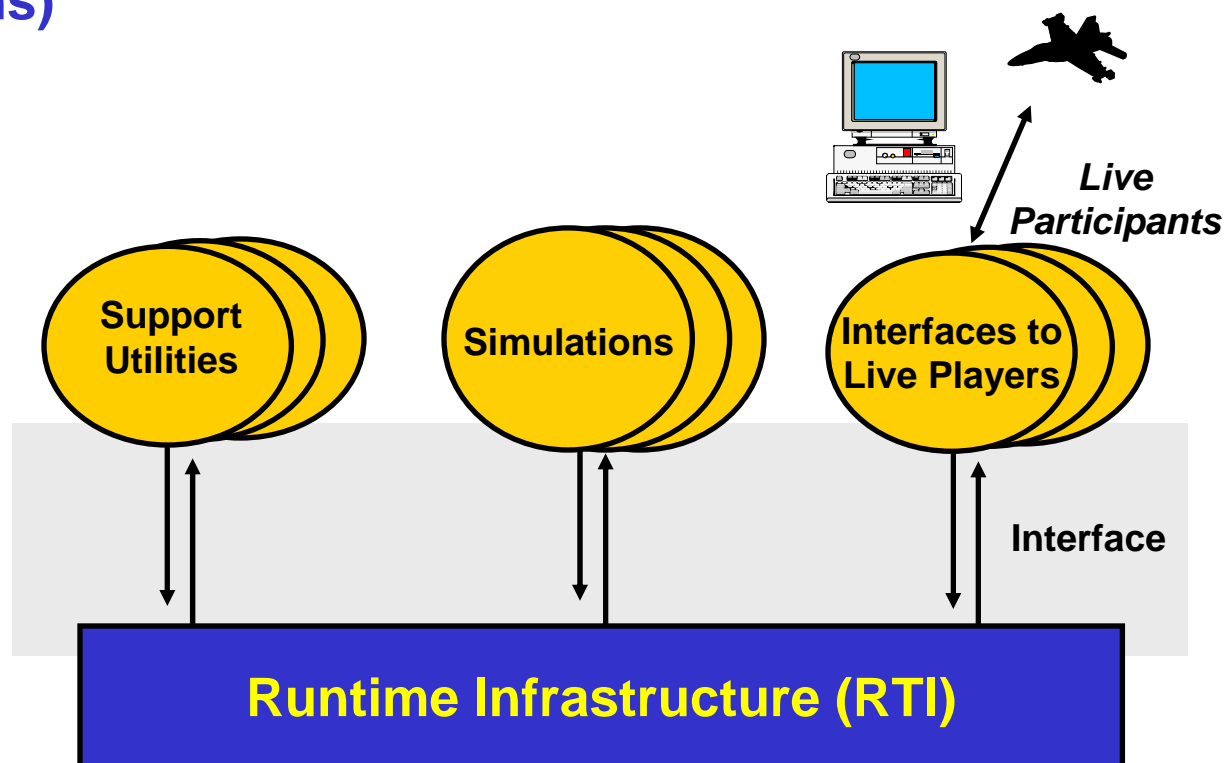
How HLA Works "Information Bus"



- A federate can publish the information that it produces to the federation
- Another federate can subscribe to information that it requires
- Publishing and subscribing are based on the FOM
- The RTI routes any relevant information to a subscribing federate – no need for federates to connect directly to other federates
- Enables interoperability and reuse
- Allows for multiple RTI implementations, including central server and peer-to-peer

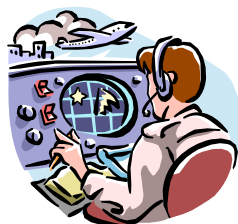
Range of HLA Usage

- Applicable to broad range of functional areas (e.g., training, contingency planning, analysis, and acquisition)
- Applicable to simulations involving pure software representations, man-in-the-loop simulators, and interfaces to live components (e.g., instrumented-weapon systems and C3 systems)

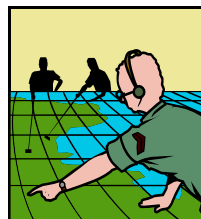


HLA – Sample Federation

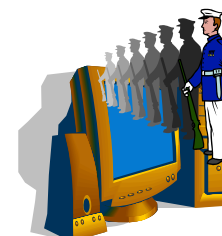
Interface to C⁴I Systems



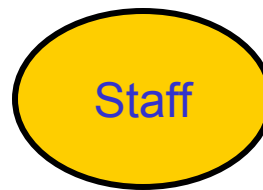
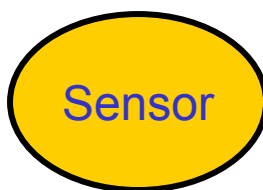
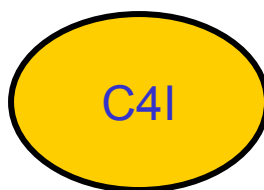
Staff-Level Training / CAX



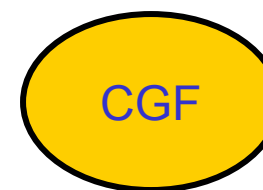
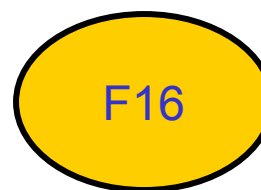
Computer Generated Forces



Interface to Live players & systems



Platform Trainers



Run-Time Infrastructure

High Level Architecture Terminology

- **A federate** – an application that may be, or is coupled with other software applications under a Federation Object Model Document Data (FDD) and a runtime infrastructure (RTI)
- **A federation** – a named set of federate applications and a common Federation Object Model that are used as a whole to achieve some specific objective
- **A Simulation Object Model (SOM)** – a specification of the types of information that an individual federate could provide to HLA federations as well as the information a federate could receive from other federates in HLA federations.
- **A Federation Object Model (FOM)** – a specification defining the information exchanged at runtime to achieve a given set of federation objectives.
- **Object Model Template** - a standardised format , rules and terminology used for describing HLA object models, i.e.
 - Objects - a thing e.g. Tank
 - Attributes - about an object e.g. position
 - Interactions - between models
- **Run Time Infrastructure (RTI)** The software that provides common interface services during a HLA federation execution for synchronization and data exchange.

What is a HLA Runtime Infrastructure (RTI)

- It is a software package designed to manage a federation in a manner consistent with the HLA specification. It is the service interface amongst federates
- It achieves data distribution, and provides a set of common services. Think of it a telephone switchboard. It provides the connection and maintains a common level of service.
- It does not maintain any information on the state of the federation, nor information on the data content and format etc.
- HLA RTIs are available from commercial vendors, national implementations; some movement to open source

RTI and Tool Implementations

- **Mainly from US, Europe and Asia**
- **Runtime Infrastructure implementations**
 - ~5 COTS RTIs
 - ~10 Additional actively developed/maintained RTIs
 - Company in-house, government projects, open-source, etc
 - ~10 Other serious RTI implementation
 - >100 Experimental or student RTIs
- **Hundreds of HLA compatible COTS applications: general purpose tools and domain specific federates**
 - Data loggers, management tools, middleware, code generators, platform simulators, visualizations, computer generated forces, ...

RTI Performance

- **Based on public information from several RTI vendors:**
 - Tens to hundreds of interoperating systems in one federation
 - 100 000 entities or more
 - Approximately 50 000 updates per second
 - High data throughput, for example 600 Mbps on Gigabit network using Windows
 - Low latency, for example: 0.130 milliseconds (130 μ s) latency between Windows hosts on a LAN
- **Actual performance may vary between RTI vendors, hardware configurations and simulators used**
- **Performance of an actual federation will generally be limited by data consumption/production rate of participating systems or network latency/bandwidth**

HLA Specifications

- **HLA Framework and Rules**
 - IEEE 1516-2000
- **HLA Federate Interface Specification**
 - IEEE 1516.1-2000
- **HLA Object Model Template**
 - IEEE 1516.2-2000
- **Federation Development and Execution Process (FEDEP) Recommended Practice**
 - IEEE 1516.3-2003
- **Recommended Practice for Verification, Validation, and Accreditation of a Federation—An Overlay to the High Level Architecture Federation Development and Execution Process**
 - IEEE 1516.4-2007

Related Standards

- **Real-time Platform Reference Federation Object Model**
 - SISO-STD-001.1-1999
- **Guidance, Rationale, & Interoperability Modalities for the RPR FOM**
 - SISO-STD-001-1999
- **Base Object Model (BOM) Template Specification**
 - SISO-STD-003-2006
- **Guide for BOM Use and Implementation**
 - SISO-STD-003.1-2006
- **Dynamic Link Compatible HLA API Standard for the HLA Interface Specification**
 - SISO-STD-004.1-2004
- **Standard for: Link16 Simulations**
 - SISO-STD-002-2006
- **Standard for Link 11 A/B Simulations**
 - SISO-STD-005-200X

HLA 1516 Framework and Rules

5 Rules for Federations

1. Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT).
2. In a federation, all simulation-associated object instance representation shall be in the federates, not in the runtime infrastructure (RTI).
3. During a federation execution, all exchange of FOM data among federates shall occur via the RTI.
4. During a federation execution, federates shall interact with the RTI in accordance with the HLA interface specification.
5. During a federation execution, an instance attribute shall be owned by at most one federate at any given time.

HLA 1516 Framework and Rules

5 Rules for Federates

6. Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT).
7. Federates shall be able to update and/or reflect any attributes and send and/or receive interactions, as specified in their SOMs.
8. Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOMs.
9. Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes, as specified in their SOMs.
10. Federates shall be able to manage local time in a way that will allow them to coordinate data exchange with other members of a federation.

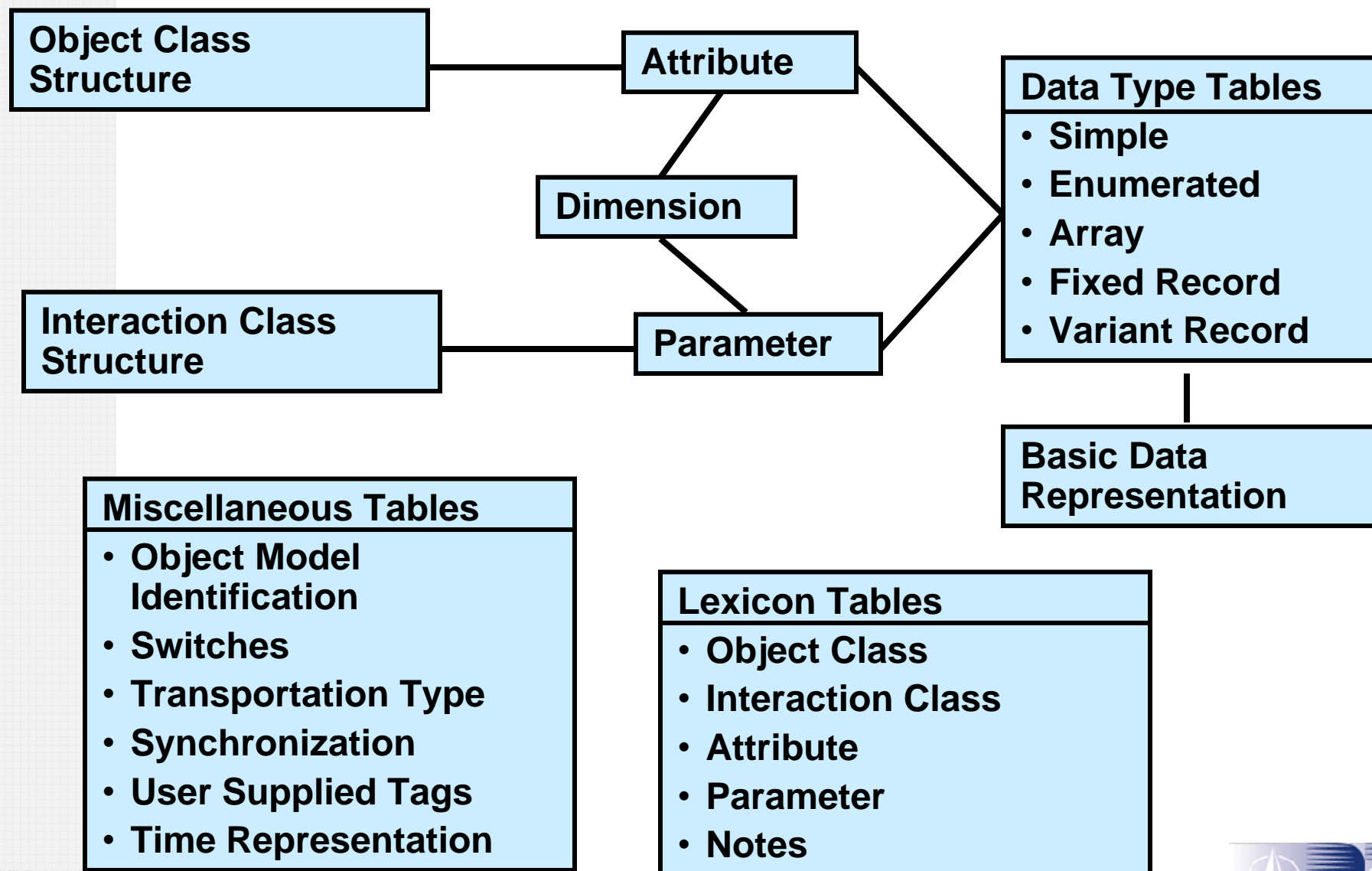
HLA Federate Interface Specification

- **Defines a set of services provided by federates and an RTI**
- **Service groups**
 - Federation Management (31 services)
 - Declaration Management (12 services)
 - Object Management (20 services)
 - Ownership Management (18 services)
 - Time Management (23 services)
 - Data Distribution Management (12 services)
 - Support Services (43 services)
- **Management Object Model**
- **FOM Document Data (FDD) XML Schema Declaration**
- **Application Programmers Interfaces (APIs) in C++, Java, and WSDL**

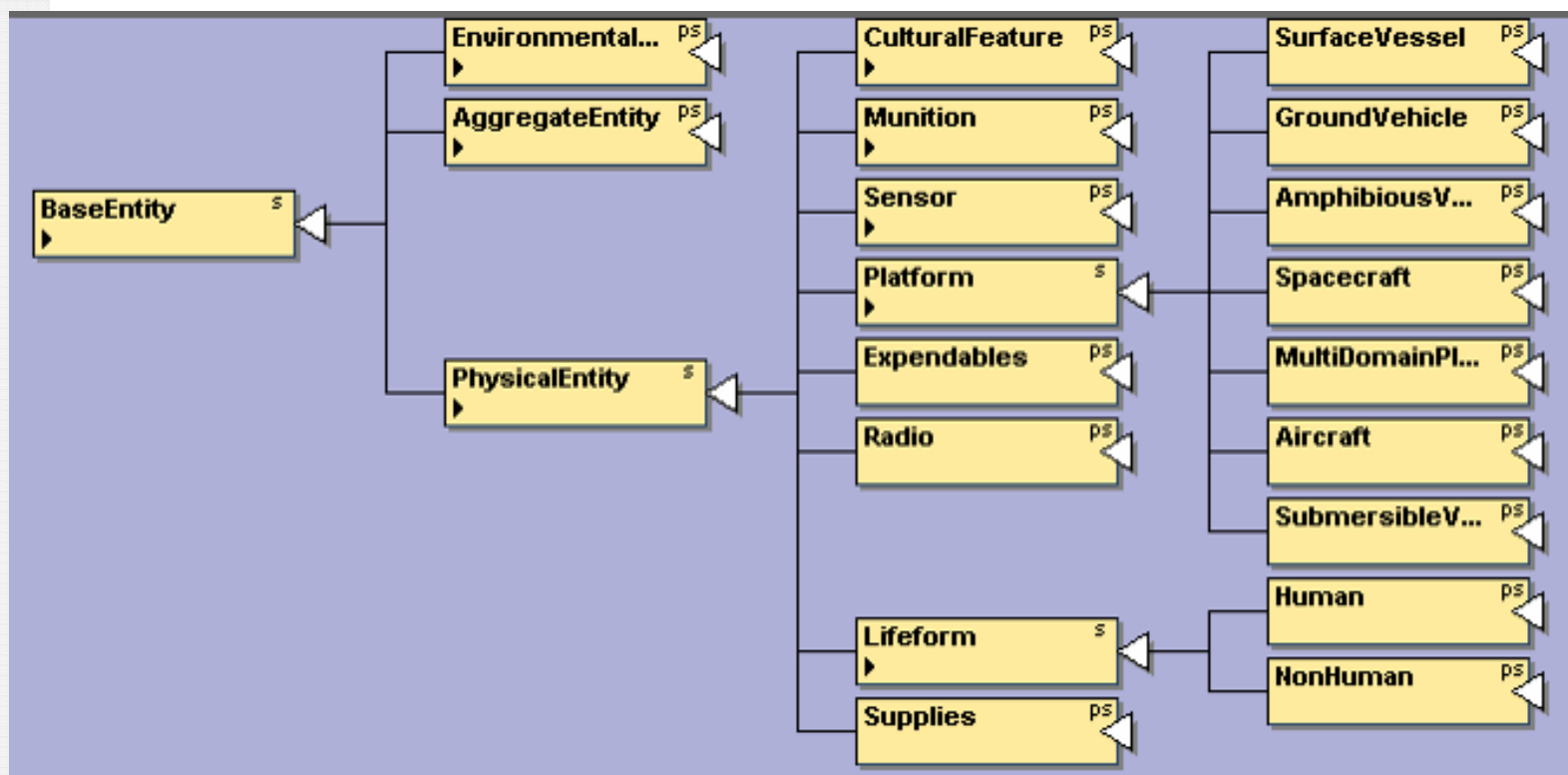
HLA Object Model Template

- A standard template for use in defining both Federation Object Models (FOMs) and Simulation Object Models (SOMs)
- Defined in terms of a series of interrelated tables
- Defines a XML data interchange format
- Provides a template to define federate capabilities for conformance checking

HLA Object Model Tables



FOM –Object Class Structure Example



The HLA Evolved Effort

- **Updating the current IEEE 1516-2000 series of technical specifications for HLA**
- **All IEEE products must be reviewed every 5 years and either reaffirmed, opened for revision and re-balloted, or retired**
- **Important sources for revision:**
 - 210 "interpretations" by the US DoD
 - Dynamic Link Compatibility API by SISO
 - Hundreds of formal comments from HLA users during three "comment rounds"

HLA Evolved Status

- **Completed three draft review rounds**
- **Completed first ballot**
 - Met thresholds for % of ballots returned and % of votes to approve the specification
 - Currently resolving nearly 500 comments
- **Will recirculate the ballot per IEEE rules**
- **Expect publication at the end of 2009**

Source: SISO Euro SIW 2008 HLA Evolved –
Improvements and Benefits: Möller et al

Benefits of HLA Evolved

- **More dynamic information models**
- **More support for incrementally growing federations**
- **More support for deploying federations in real-life, unreliable environments**
- **More support for mixing simulations from different domains**
- **More support for large and scalable federations**
- **More support for new technologies**
- **More net-centric and Web Services support**
- **More support for the latest development and deployment technologies**
- **More support for an eco-system with multiple implementations**

...and Some Good News about the Current Features

- **HLA Evolved doesn't change any semantics in the current HLA 1516 standard.**
- **It simply adds new features.**
- **If you invested time in learning HLA you will still benefit from that knowledge!**
 - Note: APIs and file formats have been updated – some effort needed to migrate applications

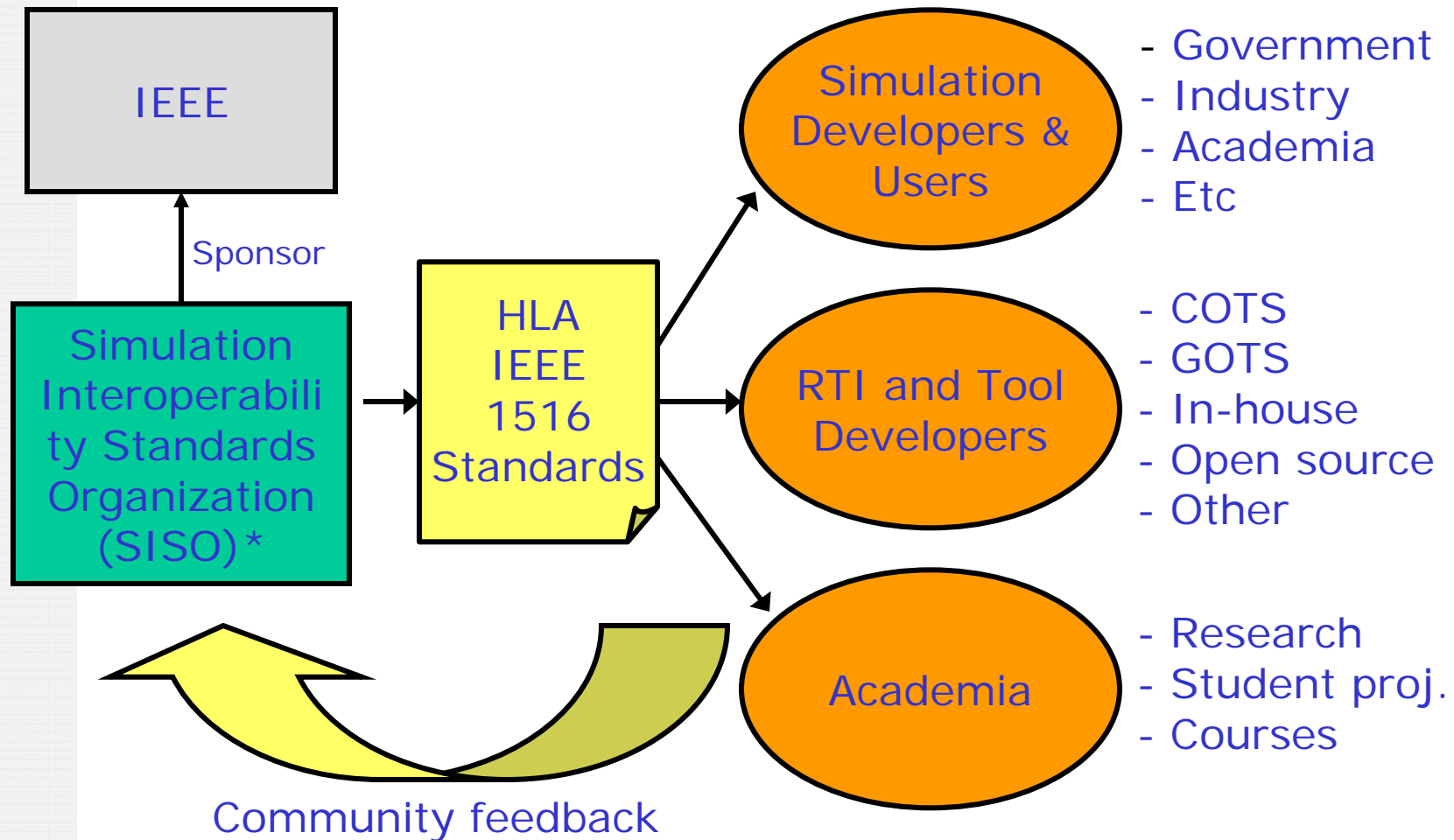
HLA Standards and Their Development

HLA – Developers and Users

- **HLA (IEEE 1516) is developed as an open international standard through a Product Development Group (PDG) as part of SISO (www.sisostds.org)**
 - SISO is an IEEE Standards Sponsor
- **The largest group of the PDG participants are from the US but there is also a substantial number of international participants**
 - NATO Standardization Agreement (STANAG) 4603 establishes HLA as the standard for NATO M&S interoperability
- **The largest HLA user base is within defense (Live, Virtual and Constructive) but there is also a growing number of civilian users**

Source: SISO Euro SIW 2008 HLA Evolved –
Improvements and Benefits: Möller et al

HLA is an Open International Standard



Representation in SISO/IEEE from organizations using HLA is critical

NATO HLA Policy

- NATO HLA policy is contained in STANAG 4603
- Basically, NATO policy is to use HLA 1516 Standard as the principle enabling architecture for Modelling and Simulation Activities
- Nations that have ratified STANAG 4603
 - Canada
 - Czech Republic
 - Denmark
 - France
 - Germany
 - Hungary
 - The Netherlands
 - United Kingdom
 - United States

Why HLA for NATO ?

- **Military operations are supported by *coalitions*,**
 - Involving different nations , different cultures,
 - New nations joining NATO ...
- **Training of multi-national joint forces and their staff shall use national M&S capabilities:**

Interoperability provided by HLA is key
- **HLA officially recognized by the highest authority in NATO, the North Atlantic Council (NAC) as early as 1998**
- **Many current and future NATO projects based on HLA**
 - examples: **FIRST WAVE** (Sept.2004), **SMART**, **SNOW LEOPARD** (starting in 2007) all supported by HLA federations !

HLA RTI Verification Testing

- Extensive test (~2000 tests) for compliance with HLA standard
- Performed on behalf of US DoD/MSCO
- Commercial, government owned, and open source
1.3 and 1516 RTIs fully or partially verified: DoD, Fraunhofer, MAK, MATREX, Pitch, Portico, Ratheon-VTC
- See <http://www.msco.mil/RTIVerificationService.html> for
 - Information to submit an RTI for testing
 - List of currently verified RTIs

Source: SISO Euro SIW 2008 HLA Evolved –
Improvements and Benefits: Möller et al

HLA Federate Compliance Testing

- Tests the use of HLA services by a single federate
- Performed by US and a growing number of NATO/PFP countries: Canada, France, Spain, Sweden, United Kingdom
- Over 250 HLA federates tested since 1997

Source: SISO Euro SIW 2008 HLA Evolved –
Improvements and Benefits: Möller et al

The NATO/PfP solution for HLA Certification

- Implement a *distributed* capability between some *voluntary nations*,
- Use an *common process* and *common software* (based on the US certification suite)
- *Evolutions controlled by NATO and PfP nations* involved in a common working group: the MSG-050 Certification Advisory Group (CeAG)
- Outside the US, HLA certification is now available in France, Spain and, Sweden, coming soon in Canada and UK

Why HLA compliance testing within NATO?

- **NATO federations could be composed of federates**
 - from very different origin,
 - with diverse levels of capability,
 - where the reliability and history of the federates is not widely known
- **HLA compliance testing and certification is**
 - ***Not*** considered as ***mandatory*** by NATO.
 - Rather considered as ***a normal step on the way to technical interoperability of simulations.***
 - ***Provided as a common service*** available to the NATO and Partners community.

Outline

Objective

M&S Introduction

HLA Overview

**Federation Resource
Considerations**

Federation Development
Process

Use Cases

Summary and Wrap Up

Topics

- Staffing/roles
- Components

Federation Resources (Staffing/Roles)

■ Problem Setter(s):

- The individual or group (customer/stakeholders) that pose the question to be answered by the federation
- Responsible for defining the problem and for funding the means to obtain the solution
- Customer/stakeholder resources include,
 - end user(s)
 - members of an Integrated Project Team
 - defence analysts

■ Problem Solver(s):

- The individual or group responsible for investigating a solution to the problem space, i.e. determines if a simulation federation can provide a satisfactory solution and if so, defines and **designs** the federation architecture and evaluation methods
- Resources include,
 - federation project manager
 - federation/federate (simulation) designers

Federation Resources (Staffing/Roles)

■ **Federation Developers:**

- The individual or group that **develop** and **integrate** the various elements of the federation, i.e. the specialist engineers who provide an operational and fully tested federated simulation
- Resources include,
 - federation systems engineer(s)
 - test engineers
 - database developers

Federation Resources (Staffing/Roles)

■ **Federation Operators:**

- The individual or group that participate in the **execution** of the federation, i.e. the people interacting with the federate components, such as a platform simulator (virtual federate) or a Semi Automated Force (constructive federate)
- Resources include,
 - military operational users / Subject Matter Experts (SMEs)
 - Instructors / role players (e.g. CGF role players)
 - human factor specialists

Federation Resources (Staffing/Roles)

■ **Exercise Controller**

- The person who is responsible for overall operation of the federation during runtime **execution**, re: starting/stopping/pausing the exercise

■ **Verification & Validation (V&V) Agents:**

- The individual or group designated by the customer sponsor to perform verification and validation tasks on a federation or single federates
- Can be a subject matter expert within the application domain of the federation, a software/hardware specialist or a tester, who is in charge of conducting tests according to FEDERATION TEST CRITERIA
- Involved across all federation activities (e.g. **requirements capture, design, development**) and also participate in the operation of the federation

Federation Resources (Staffing/Roles)

■ **Federation Analysts**

- The individual or group responsible for defining data capture / analysis requirements for After Action Review (AAR)

Federation Resources (Staffing/Roles)

- Depending on the complexity of the federation one individual might fulfil more than one role across federation **design, development and execution**

Federation Resources (Components)

- **Network infrastructures**
 - Level of security
 - Bandwidth considerations
 - Quality of service (delivery)
 - Point of presence / availability
- **Availability of federated capable facilities**
- **Common simulation context (provision of common/credible federation components)**
 - Synthetic representation of the natural and physical environment
 - correlated terrain data (terrain elevation and feature data) and terrain databases
 - 3D models (e.g. vehicles, buildings, targets, etc)
 - Computer Generated Forces (CGFs)
 - 'red' (threat) + 'blue' force behaviours (e.g. physical and performance data)
 - communications infrastructure (C2 aspects)
- **Simulation systems / models**
 - Portable model components and model performance data
- **Federate and federation test tools**

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**Federation Development
Process**

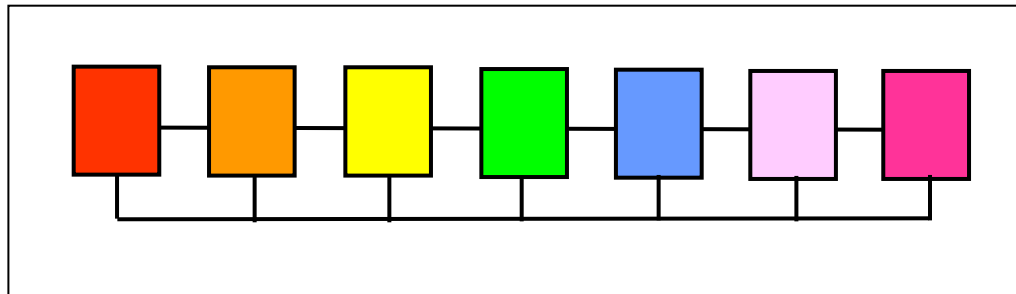
Use Cases

Summary and Wrap Up

Topics

- Federation Development and Execution Process (FEDEP)
- Federation Agreement Document

HLA Federation Development and Execution Process (FEDEP)



- A systems engineering process model to combine individual applications (federates) into distributed simulation environments (federations),
- First a DoD Standard (FEDEP 1.5, Dec. 99, based on HLA DoD 1.3),
- Standardized as IEEE 1516.3-2003
- Not specific to HLA, but written using HLA terminology
- Currently under revision:
 - will be replaced by the Distributed Simulation Environment Engineering Process (DSEEP) as IEEE P1730.

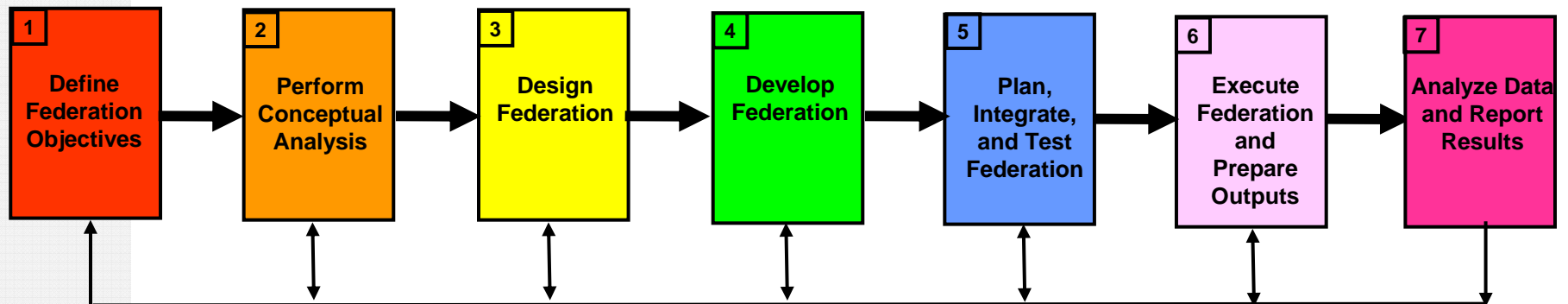
FEDEP Description

- Standardized systems engineering process
- Recommended practice (IEEE STD 1516.3)
- Federation characteristics
 - High Level Architecture (HLA) federates
 - Distributed environment
- Benefits of FEDEP
 - Re-use
 - Information sharing
 - Interoperability

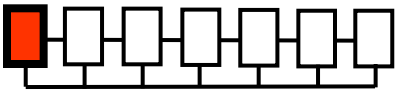
FEDEP Seven Step Model

Design and Development

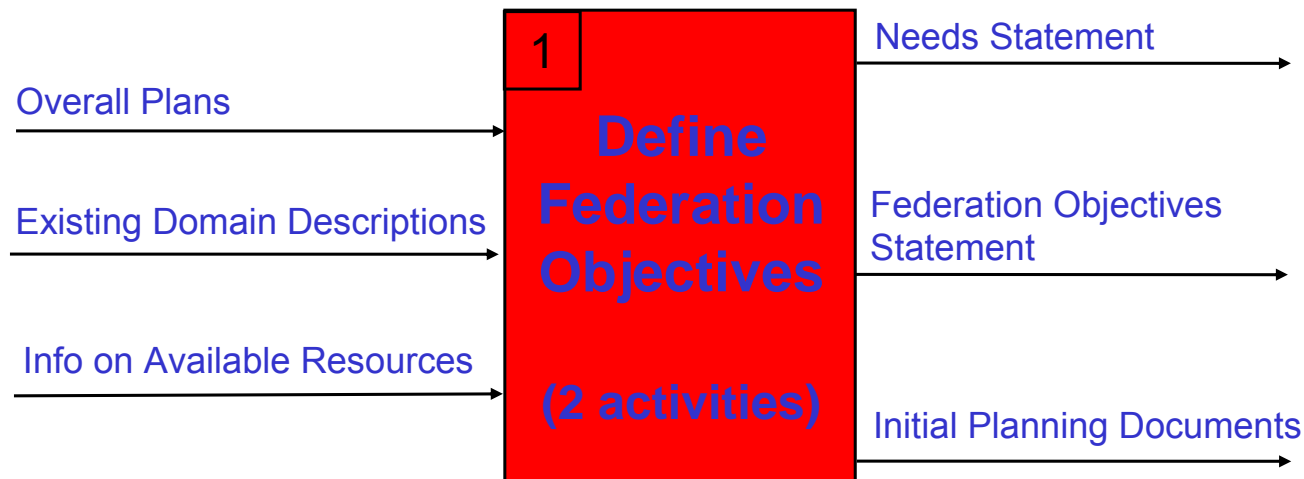
Integration and Execution



Iterative Development Flow

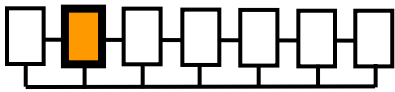


Step 1: Define Federation Objectives

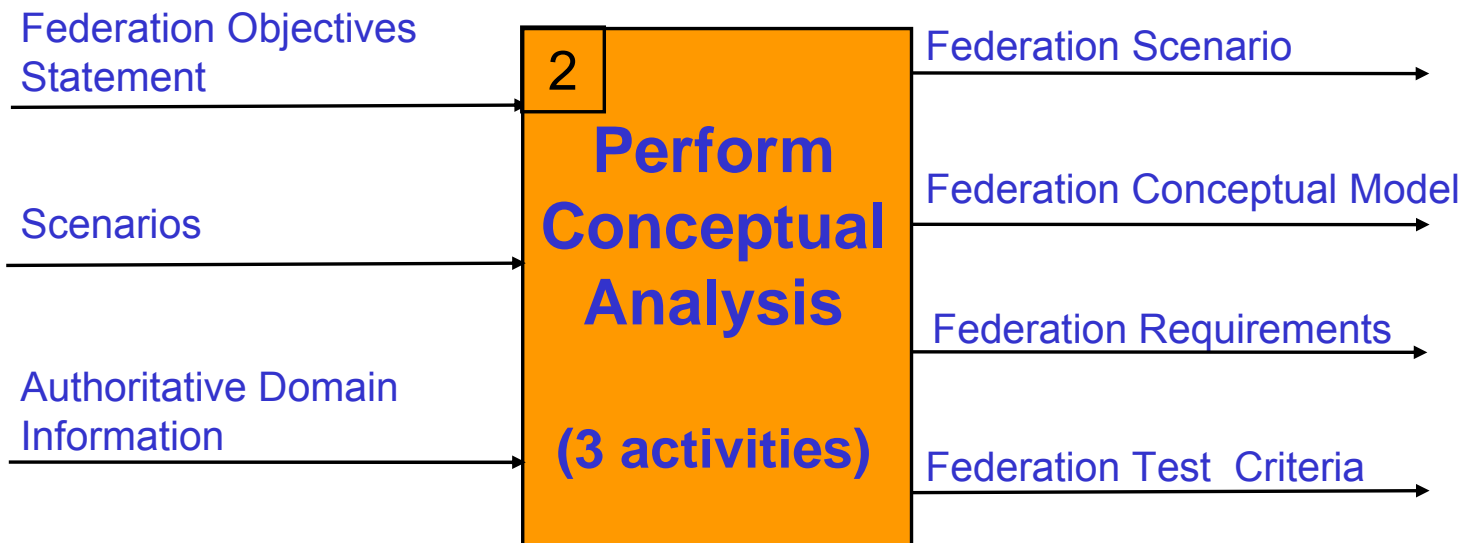


Considerations

- What does the “sponsor” want to achieve?
- How is success or failure going to be measured?
- What are the requirements?
- What’s the best way to get there?
- What are you just stuck with?
- The sponsor’s objectives need to be turned into detailed requirements.
- Note: the level of effort required will vary



Step 2: Conceptual Analysis



Considerations

- Define time management requirements (real-time versus slower or faster than real-time)
- Discuss Fidelity and Resolution ...

What is a scenario?

- **1) Description of an exercise (“initial conditions” in military terms). It is part of the session database that configures the units and platforms and places them in specific locations with specific missions.**
Source: NATO Modeling and Simulation Master Plan
- **2) An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives.**
Source: NATO Modeling and Simulation Master Plan

Fidelity vs. Resolution



VS



Fidelity

Resolution

- Resolution and Fidelity are not the same
- You can have one and not the other
- Not necessarily a bad thing –
It depends on what you are trying to accomplish

Fidelity

Fidelity: The accuracy of the representation when compared to the real world.

DoD M&S GLOSSARY, Jan 98

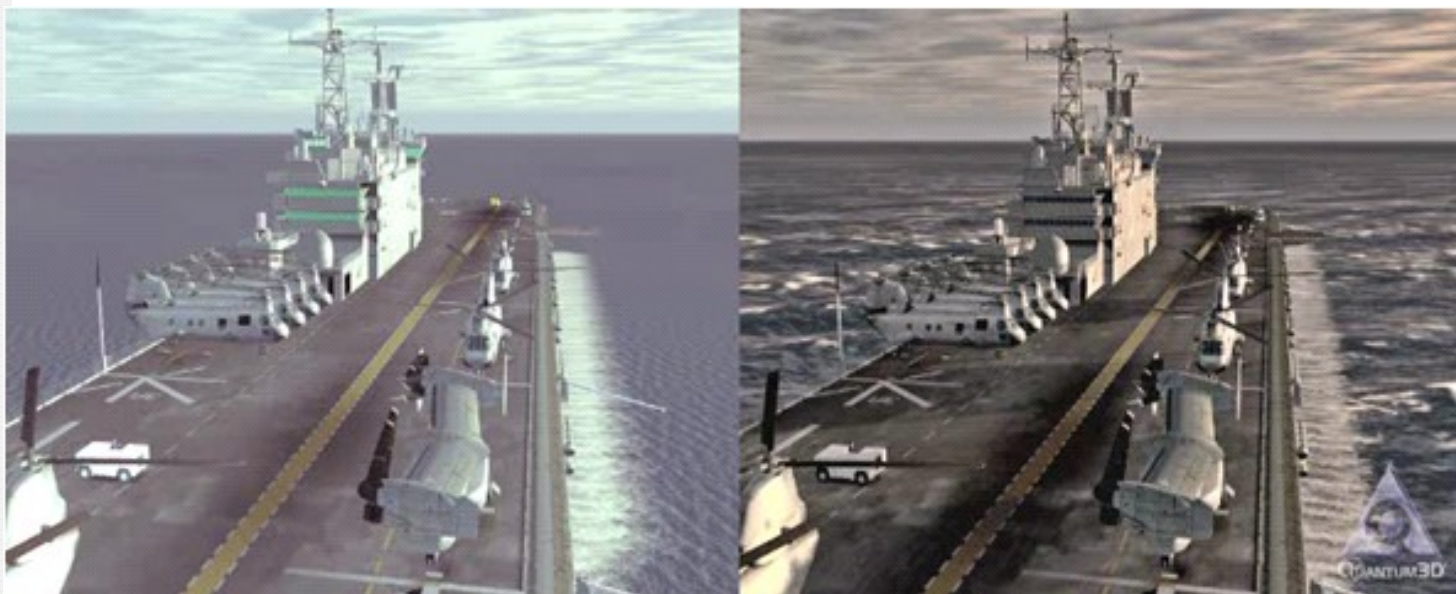


A model or simulation is said to have fidelity if it accurately corresponds to or represents the item or experience it was created to emulate. In other words, **how does it act?**

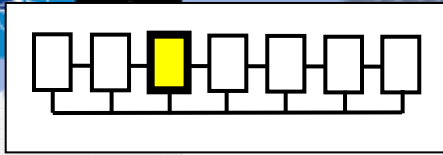
Resolution

Resolution: The degree of detail and precision used in the representation of real world aspects in a model or simulation.

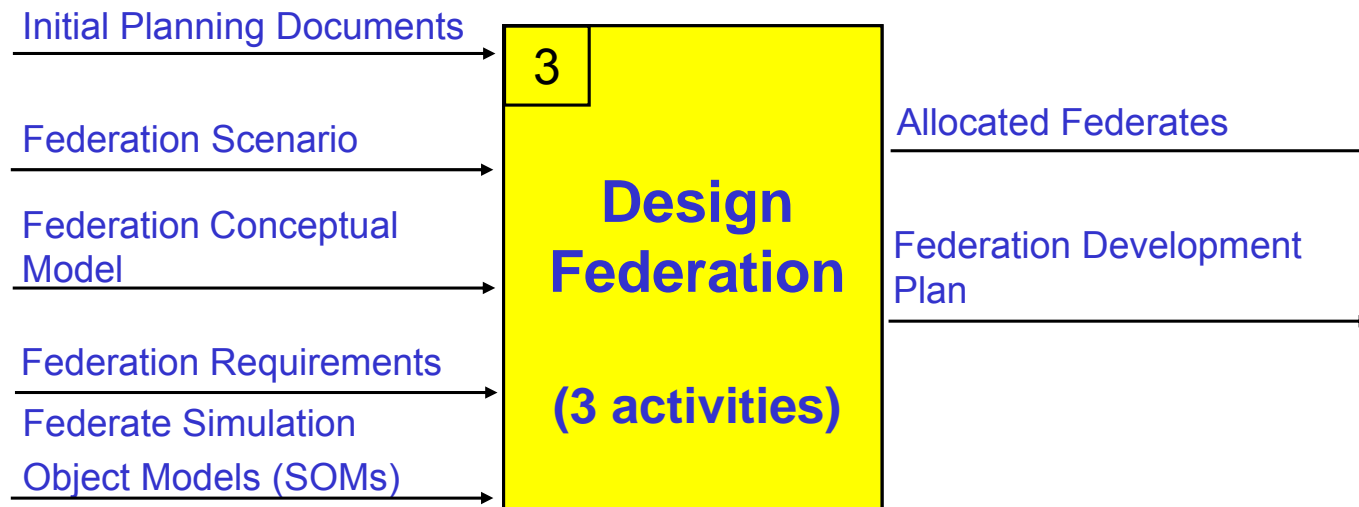
DoD M&S GLOSSARY, Jan 98



Resolution means the fineness of detail that can be represented or distinguished in an image. **How does it look?**



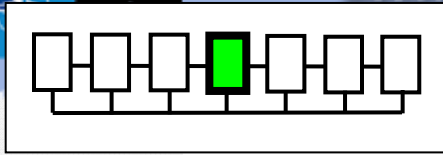
Step 3: Design Federation



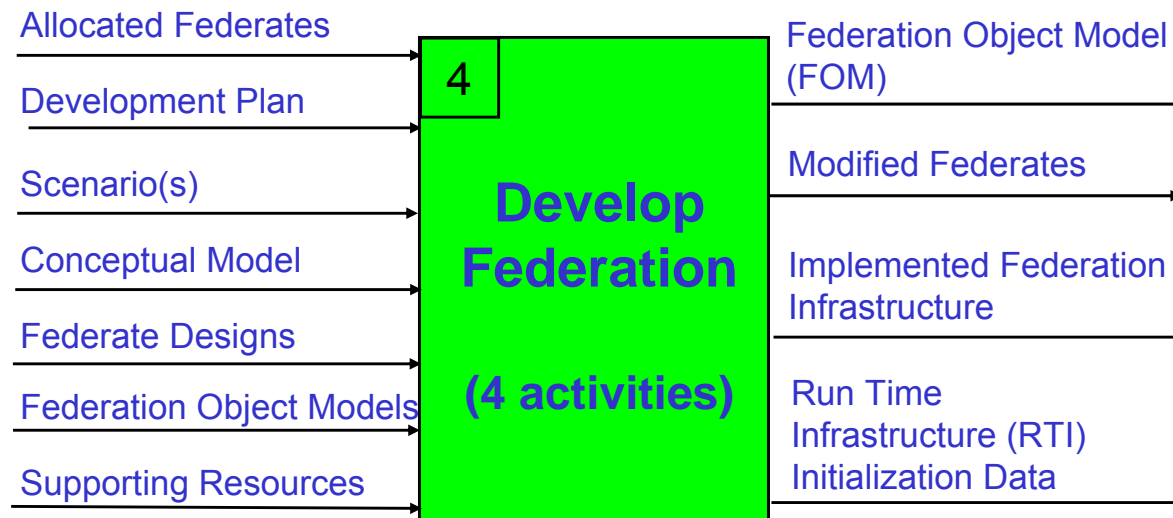
Considerations

The sponsor's requirements need to be met.

- Existing software, new software, and integration.
- Security considerations.
- Who is going to do the work?
- When is all this going to happen?



Step 4: Develop Federation



Considerations

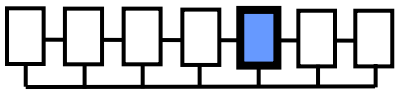
Development is the implementation of the plan. Some of the things that happen during development are:

- Software is created.
- Networks are stood-up.
- Physical infrastructure is established
- Contracts are let, resources are allocated.
- Hardware and software are acquired.
- Time management agreements are established.

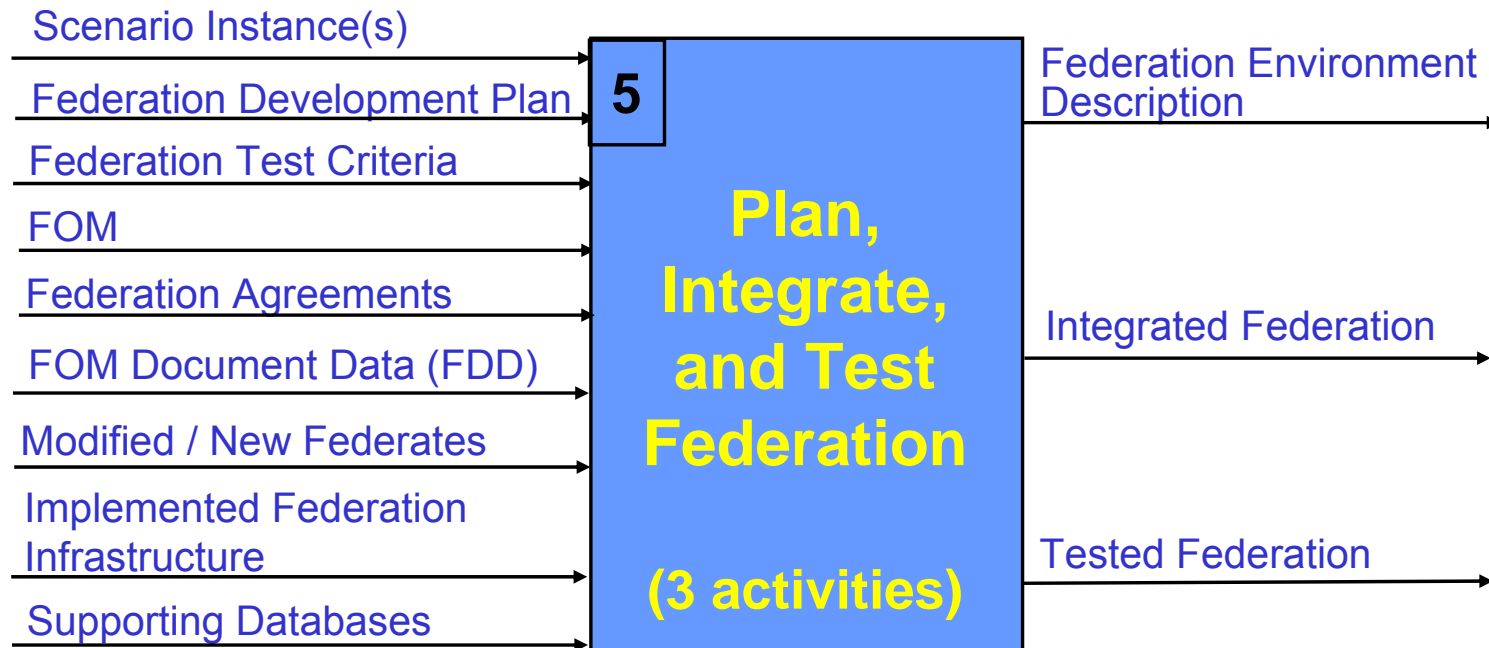
In Step 4: Develop Federation ...

Development is the implementation of the plan. Some of the things that happen during development are:

- Software is created.
- Networks are stood-up.
- Contracts are let, resources are allocated.
- The pieces are integrated.
- Hardware and software are acquired.
- Testing.
- Training.

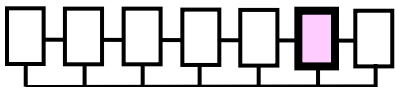


Step 5: Plan, Integrate, and Test Federation

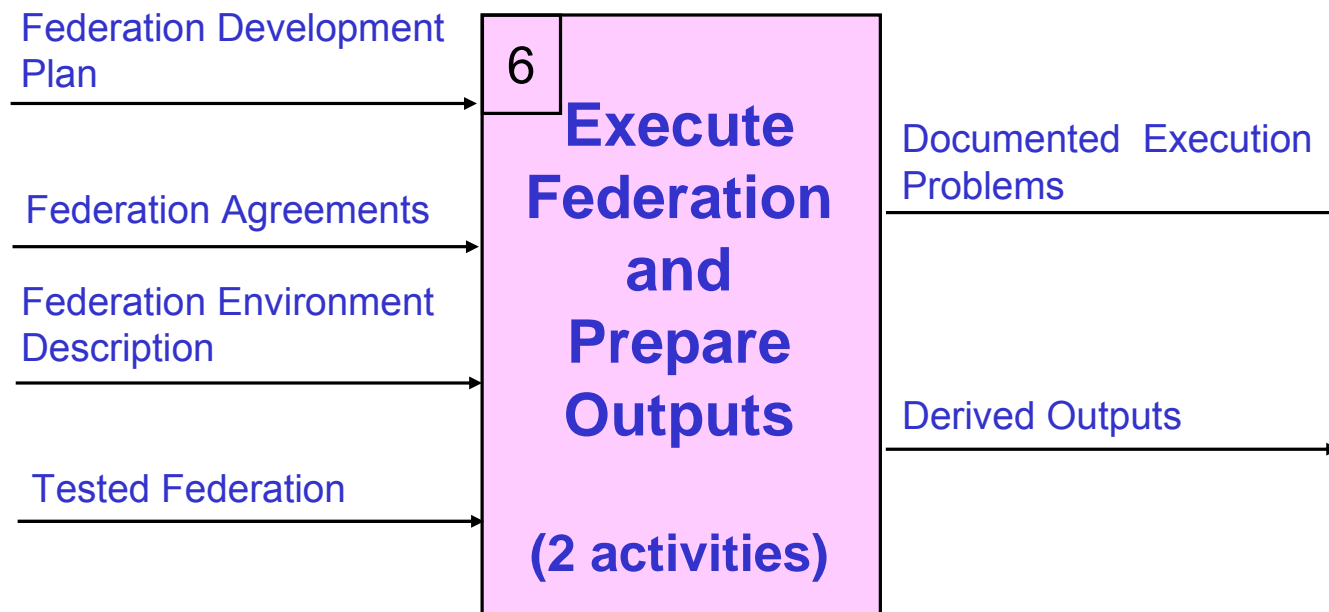


Considerations

- The pieces are integrated.
- Testing.
- Training.

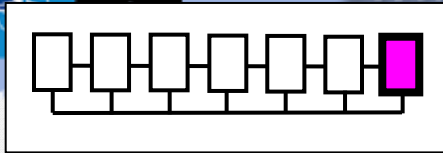


Step 6: Execute Federation and Prepare Outputs

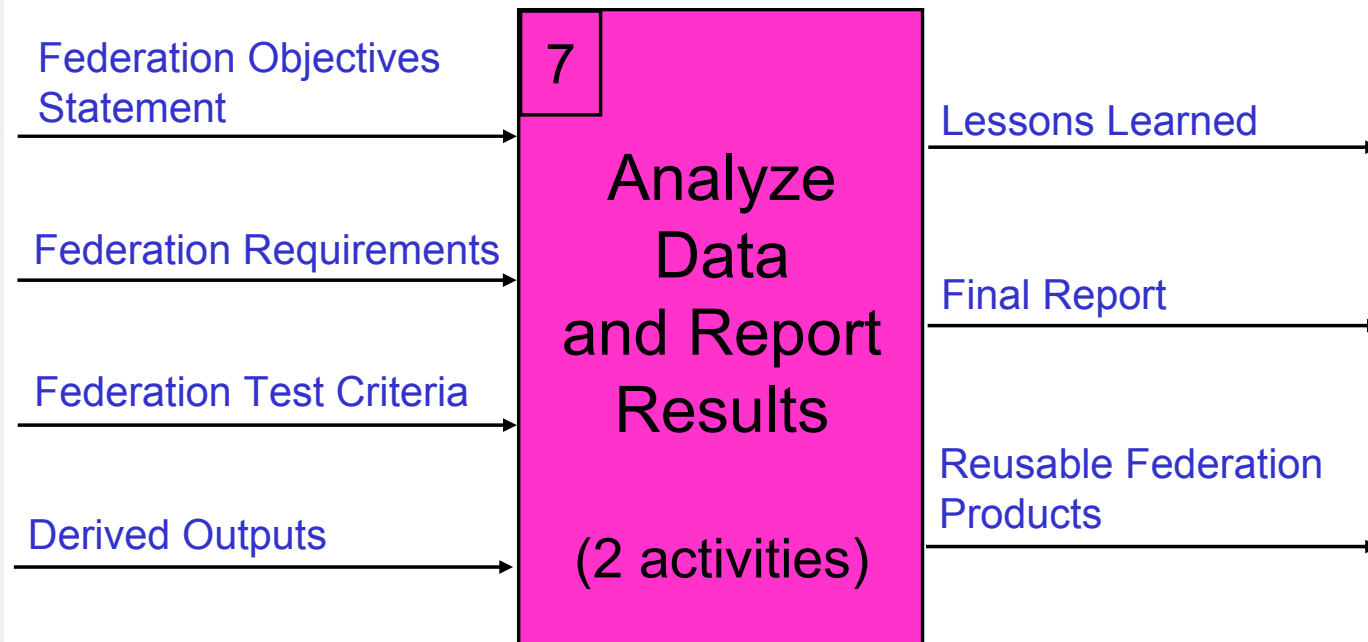


Consideration

Execution often leads to changes in requirements, or uncovers problems, and iteration between execution and previous stages is normal.



Step 7: Analyze Data and Evaluate Results



Considerations

Was the federation “fit for purpose”?

Can any of the work be reused?

Are more iterations required to meet the sponsor’s objectives?

Security

- **Security considerations are pervasive throughout the FEDEP**
 - **Step 1 - Define Federation Objectives**
 - Identify security requirements
 - **Step 2 - Perform Conceptual Analysis**
 - Define security requirements for hardware, network, data, and software
 - **Step 3 – Design Federation**
 - Analyze, and if necessary, refine initial security risk assessment and concept of operations
 - Develop security plan
 - **Step 4 – Develop Federation**
 - Establish security procedures
 - **Step 5 – Plan, integrate, and test federation**
 - Perform security certification testing

Risk

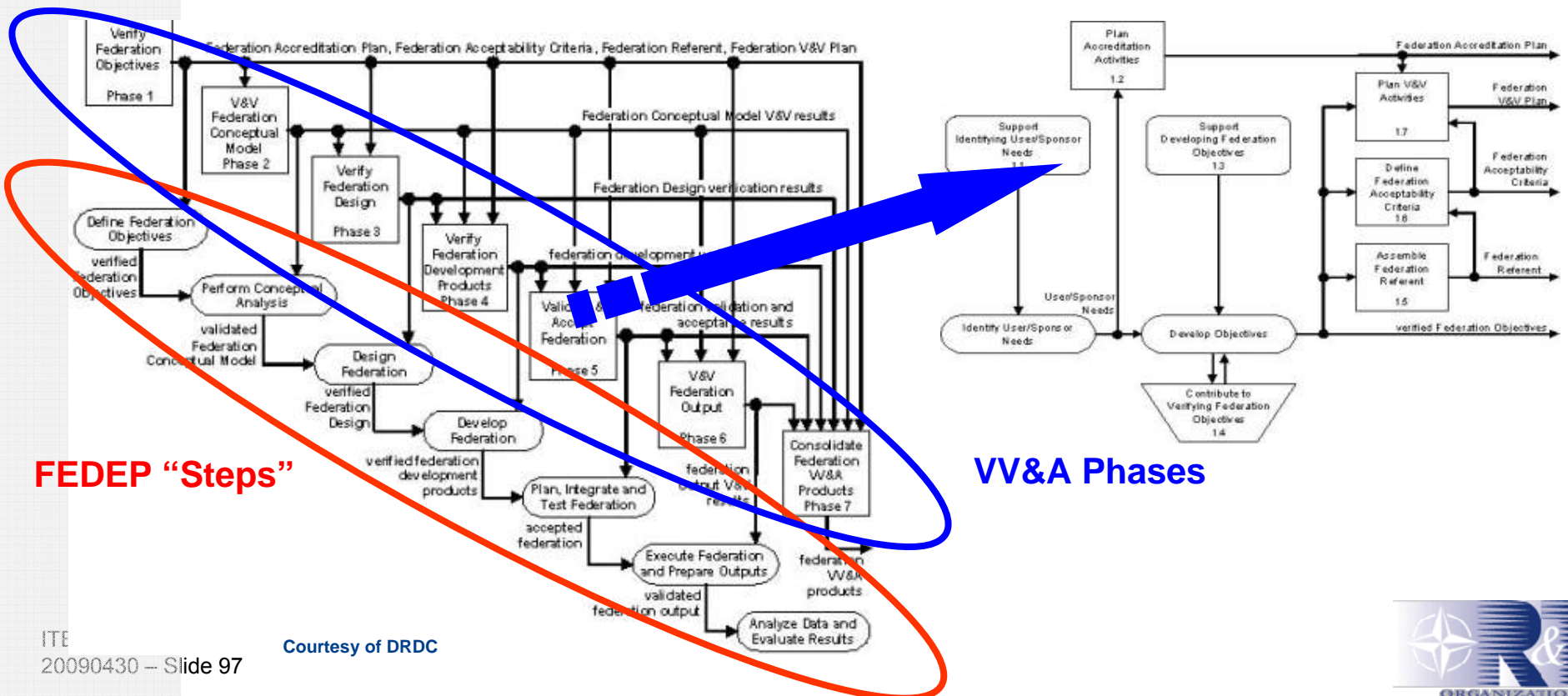
- **Consider risk in all steps of the FEDEP**
- **A measure of the probability and severity of undesired effects often taken as the simple product of probability and consequence**
- **Impact**
 - Domains: health, environment, finance...
 - Levels: negligible, marginal, critical, catastrophic
- **Likelihood of occurrence**
 - Low, medium, high
 - Probability Theory
- **Residual uncertainty**
 - Upper bound for the probability of occurrence

Processes and Tools Considerations

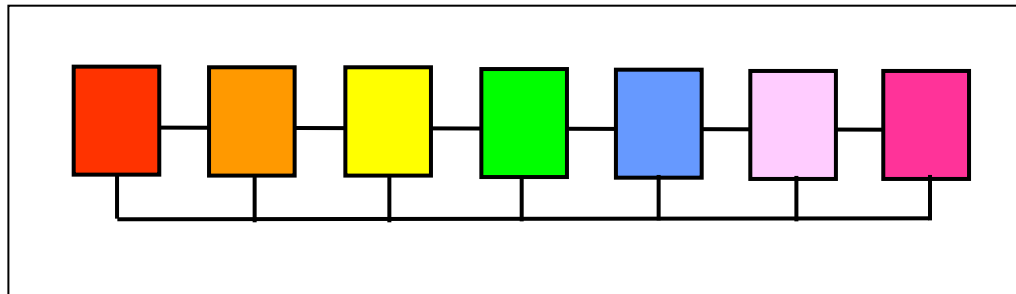
- **Are there processes and tools available?**
- **Yes**
 - Reports and papers for guidance
 - Development processes tailored to M&S
 - Evaluation Processes such as VV&A
 - M&S tools available for a wide range of applications

SISO FEDEP V&V Overlay

- Diagrammatic mapping of V&V activities to the steps of the Federation Development and Execution Process (FEDEP), including assignment of responsibilities
- Standardized as IEEE 1516.4



FEDEP Summary



- The FEDEP is a process *model*; it is not the process itself. It must be tailored for the specific problem that you are trying to solve with simulation.
- You must be specific in the capabilities you need before you can determine the simulations you need.

The future: the DSEEP

- **Distribute Simulation Environment Engineering Process**
- **A new IEEE recommended practice to be published end-1999 (IEEE 1730)**
 - Developed by enthusiastic and experienced people
- **A Generic engineering process dedicated to Distributed Simulation in general**
 - 3 Annexes related to DIS, HLA, TENA;
 - Many improvements due to lessons learned (particularly on the 3 first steps)
 - More specific on documentation and relationship between different documents ...

Federation Agreements (FAs)

- **FAs should be considered as an integral part of overall Federation Design**
 - crucial to federation success (whether federation agreements are formally documented, implicit or ad-hoc)
- **A Federation Agreement Document (FAD) is NOT a federation design document**
- **FAs should be used to clarify expectations, constraints and responsibilities between 'members' of a federation**
- **FAs exist throughout the federation lifecycle (particularly important for long-lived or re-used federations)**

Structured Federation Agreements

■ **The “5 W’s design pattern” for FAs:**

- What is agreed to (content)
- When is it applicable (moment in time)
- Who is affected by it (involved parties, federates)
- Where it applies (circumstances, conditions)
- Why this agreement was made (rationale)

■ **EXAMPLE: Synced Local Time**

- What: Federates will sync local clocks thru NTP
- When: Federate joins federation
- Who: All Federates
- Where: Always
- Why: local Logs should have synced timestamps

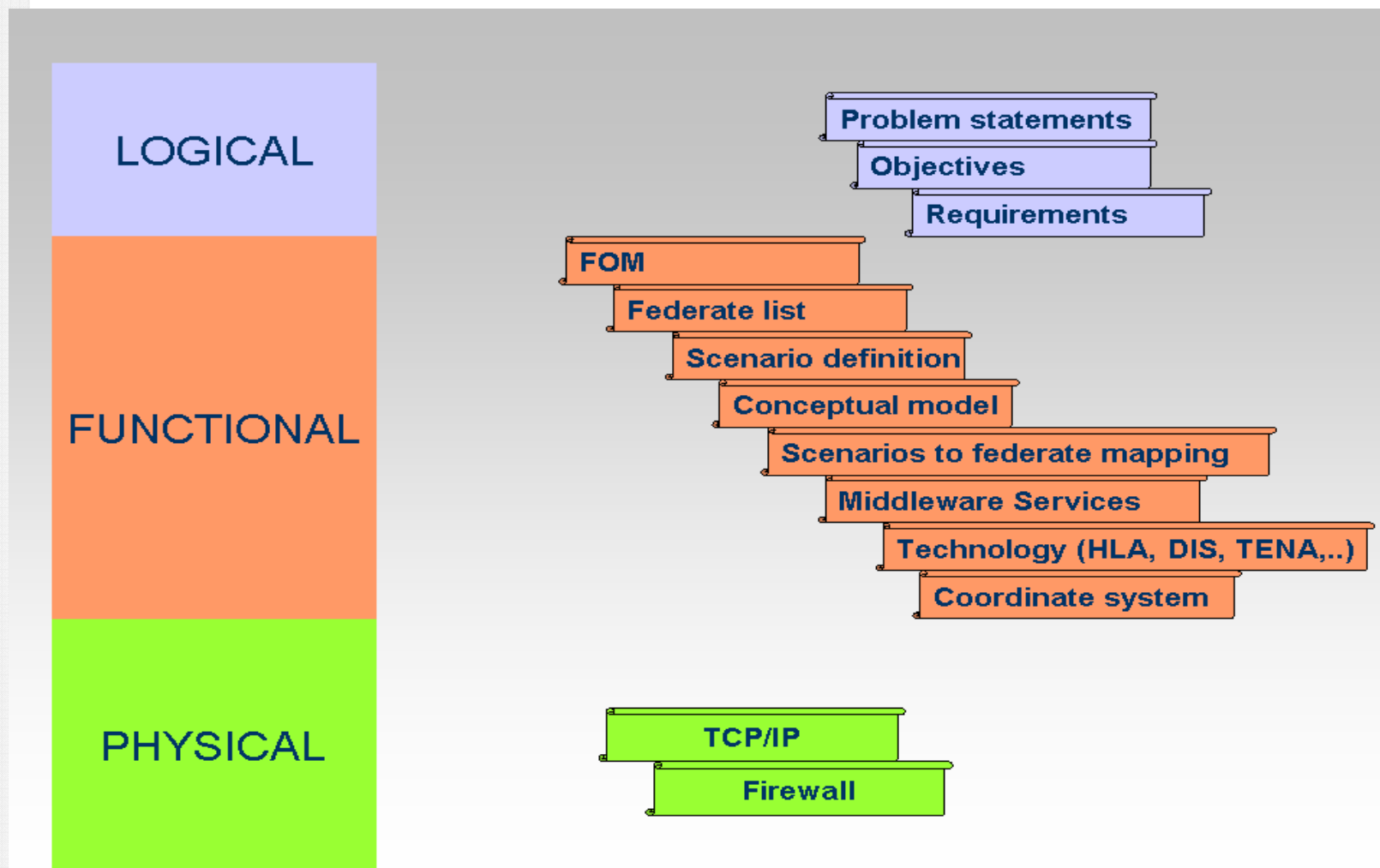
Need for Structured Federation Agreements

- **Structured FAs allow federation stakeholders:**
 - To understand/reuse FAs across federations
 - To compare FAs across federations
 - To exploit any automated tools to access FA repositories
 - To check completeness

Federation Agreement Documents (FAD)

- Spell out exactly **what** is to be developed and delivered, and **how**
- Determine a disciplined approach to federation **design, development, and execution** (e.g. use of IEEE 1516.3 FEDEP/DSEEP)
 - Ensure appropriate level of V&V and assessment for use
- **Identify requirements for component resources**
 - Federation (common) components and tools, e.g. environment datasets/databases, 3D models, Computer Generated Forces (CGFs), etc
 - Federation Information Products
- **Determine key people resources**
 - Roles and Responsibilities (who does what/when?)
 - Who participates
- **Determine federation analysis requirements**
 - Form and natures of results
 - What data needs to be captured

Federation Information Products



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Topics

- French Alliance Federation
- Canadian Federation
- UK Federation

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Summary and Wrap Up

Summary

- Modeling and Simulation has proven value that saves lives and dollars and increases capabilities
- Distributed simulation is an effective method for combining and reusing simulation in a cost-effective manner
- HLA provides a open-standards based method of implementing distributed simulation
- A variety of talents and resources are required to effectively employ HLA, or any simulation application
- An proven systems engineering process (FEDEP) exists to guide users in the use of HLA